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APPENDIX

PVT RESULTS

PVT Lapse Duration

The analysis discussed in the main body of this report focused on the frequency of performance lapses in crewmembers, whereas this analysis concerns the length or duration of lapses. In fact, the focus in this appendix concerns not only lapse duration, but also the speed of responses that comprise the poorest performance in a PVT trial. There is laboratory evidence that the speed of the slowest 10% of RTs in a trial decreases as sleep-based fatigue increases. The issue cannot be assessed statistically, however, without considering the proportionality between the mean of raw RT scores and the standard deviation (see ref. 6, especially fig. 2 therein). To correct for this proportionality and the overall distortion introduced by very long RTs, we performed a reciprocal transformation on the 10% of RTs that were of the longest duration in each trial, yielding response speeds for the lapse domain, and then analyzed the results using ANOVAs.

Figure 29 shows the average speed of the slowest 10% of PVT responses for NRG and RG for each trial of each study flight leg. (*Note: Because of the reciprocal transformation, poorer performance is reflected in a downward direction in figs. 28-30.*) As with previous performance parameters in this report, the NRG displays far greater range of average speeds across flight legs and trials than the RG, with drops in mean speed especially evident on the third in-flight performance trial on study flight legs 2, 3, and 4. The three-way ANOVA confirmed this picture. The main effect for condition was marginal ($F_{1,19} = 3.54$, $p < .075$), whereas the main effects for flight leg ($F_{3,57} = 6.44$, $p < .001$) and trial ($F_{3,57} = 8.44$, $p < .0005$) were significant. The condition by flight-leg interaction was significant ($F_{3,57} = 3.11$, $p < .033$), as was the flight leg by trial interaction ($F_{9,171} = 4.07$, $p < .0005$). The condition by trial interaction was marginal ($F_{3,57} = 2.56$, $p < .064$). The F-ratio for the three-way interaction was not significant ($F_{9,171} = 0.51$).

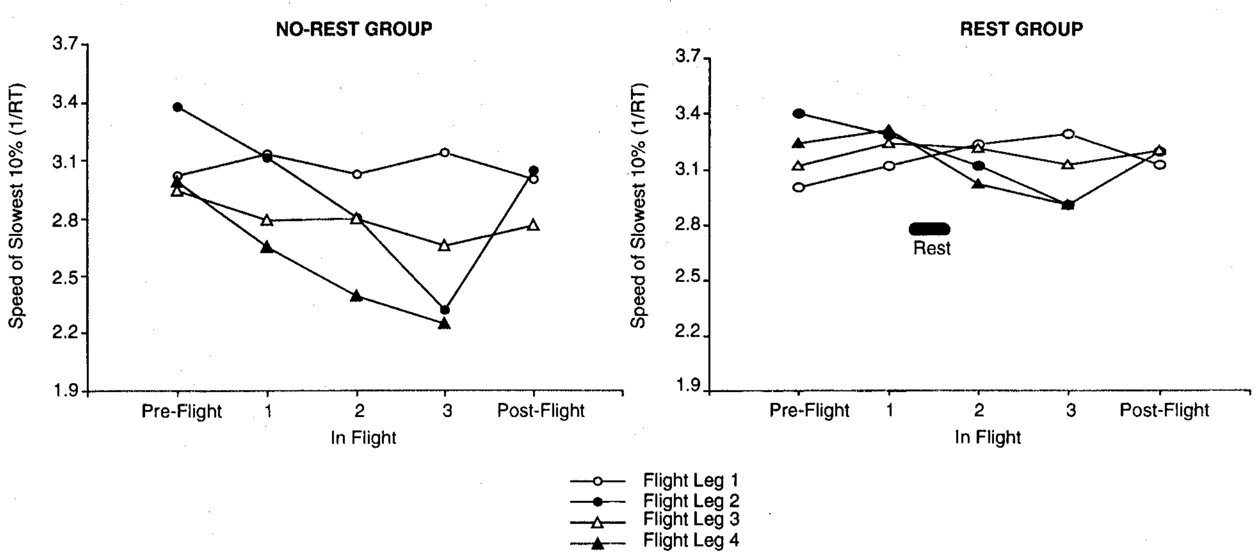

Figure 29. Mean response speed of lapses (the slowest 10% of PVT responses within each trial) for RG and NRG across each flight leg. The reciprocal transformation results in decreases indicating poorer performance (slower speed).

Two-way ANOVA revealed that there were no significant main effects or interactions on day-flight leg 1. On night-flight legs 2 and 4 there were significant main effects for trials (leg 2 $F_{4,76} = 9.99$, $p < .0005$; leg 4 $F_{3,57} = 5.48$, $p < .002$), indicating that response speed was slowing as flights progressed. Most important, there were significant main effects for condition on flight leg 3 ($F_{1,19} = 4.44$, $p < .05$) and flight leg 4 ($F_{1,19} = 5.40$, $p < .031$). Overall, the RG averaged less slowing of responses in the lapse domain than did the NRG, especially during these later flight legs. Figure 30 illustrates this effect using data from study flight legs 1 and 4. By flight leg 4 the speed of responses in the lapse domain for the NRG had decreased 21%-28% midway and late in the flight, compared to flight leg 1. No such decline in the speed of the slowest 10% is evident in the RG, suggesting that the nap prevented it.

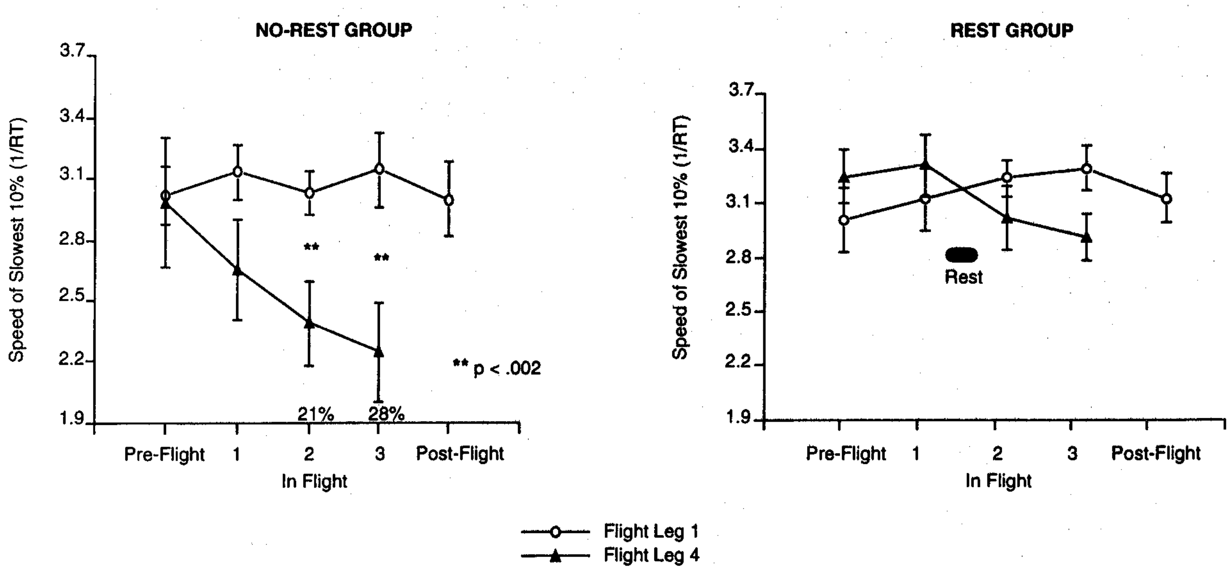

Figure 30. Mean response speed (S.E.) of lapses (slowest 10%) for RG and NRG for day-flight leg 1 and night-flight leg 4. Decreases indicate poorer performance (slower speed). Asterisks indicate significant differences with group by paired t-tests at specific time points.

Figure 31 shows the difference in lapse domain response speed between the two groups for data averaged across the four study flight legs. The NRG response averaged 12%-15% slower than those of the RG during in-flight trials 2 and 3.

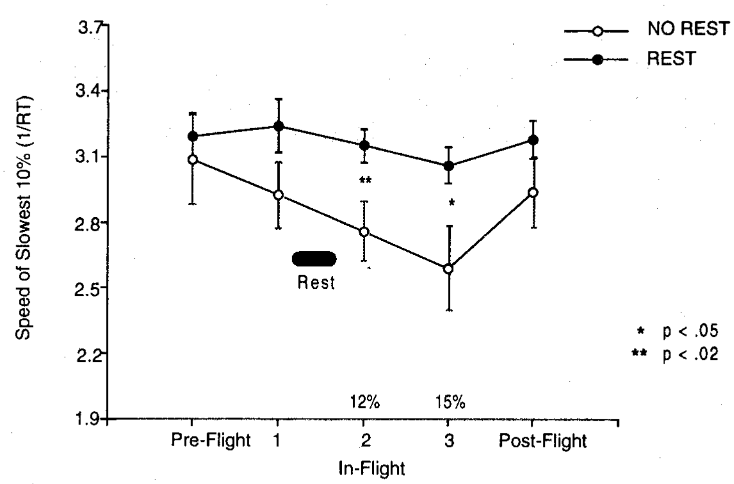

Figure 31. Mean response speed (S.E.) of lapses (slowest 10%) for RG and NRG collapsed across all four flight legs. Decreases indicate poorer performance (slower speed). Percentages indicate differences between groups' means at PVT trial times. Asterisks indicate significant differences between groups by independent t-tests at specific time points.

PVT Optimum Response Time

Optimum response times are the opposite of the lapse domain. They refer to the 10% of RTs in a PVT trial that have the shortest durations, and therefore reflect the best performance on a given trial. Although it has often been assumed that sleep loss and fatigue should not affect the very fastest reaction times, there is now ample evidence that this assumption is incorrect (ref. 6). Diminution of "best effort" as reflected in small but statistically significant shifts in the upper 10% of responses has been found in both the classic research on the effects of sleep loss on performance (ref. 67), and in recent studies (ref. 60).

Performance from the present study was analyzed to determine whether the Rest condition had any effect on optimum responses, as well as to ascertain what, if any, effects night flights had on RTs in the domain of "best effort." In conducting these comparisons, the same basic analytic strategy used with other performance parameters was followed, except that no distribution-free metric or transformation was necessary because optimum responses have exceedingly low variability (by definition they are uninfluenced by lapses).

Figure 32 displays the average optimum RTs for no-rest and rest groups for each trial of each study flight leg. (Note that because these analyses use raw RT scores, poorer performance is reflected in an upward direction in figs. 32-34.) It is clear upon examining the figure that, as expected, there is little variability across trials and flight legs for either group, although there appears to be some change evident in the NRG that is absent in the RG. The three-way ANOVA yielded a main effect for condition ($F_{1,19} = 7.79$, $p < .012$), flight leg ($F_{3,57} = 2.90$, $p < .042$), and trial ($F_{3,57} = 12.70$, $p < .0005$). There were significant interactions for condition by trial ($F_{3,57} = 3,55$, $p < .02$), and for flight leg by trial ($F_{9,171} = 2.29$, $p < .022$). The overall interaction was not significant.

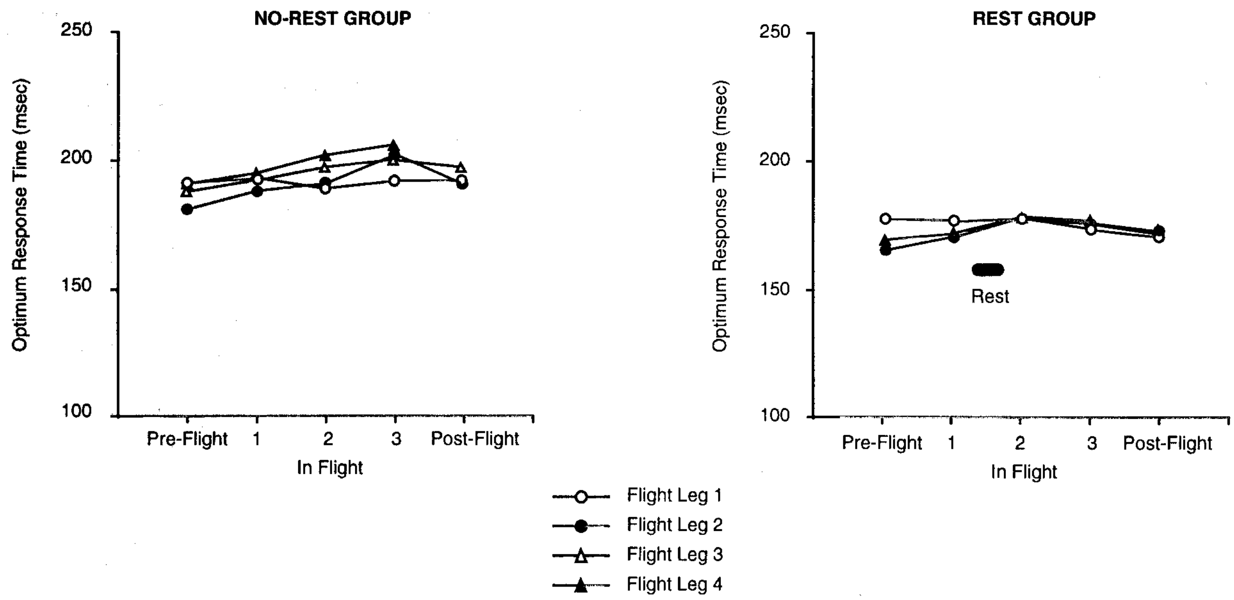

Figure 32. Mean optimum response times (the fastest 10% of RTs within each PVT trial) for RG and NRG across each flight leg. Increases indicate poorer performance.

Figure 33 compares the means for flight legs 1 and 4 within each group. There is a nonsignificant trend for optimum performance to be slightly slower at TOD during leg 4 in the NRG. ANOVA within each flight leg yielded no significant main effects or interactions on flight leg 1—the two groups were performing comparably at this time, although there was a trend for the RG to average slightly faster optimum RTs ($F_{1,19} = 4.05$, $p < .058$). On study flight legs, 2, 3, and 4, the NRG was significantly slower in optimum responses than the RG (main effect for condition: leg 2 $F1,19 = 7.93$, $p < .014$; leg 3 $F_{1,19} = 8.16$, $p < .01$; leg 4 $F_{1,19} = 10.01$, $p < .005$). An analysis of covariance, with the first trial on leg 1 as the covariate, reduced these main effects due to condition, but did not eliminate them (leg 2 $F_{1,18} = 3.71$, $p < .07$; leg 3 $F_{1,18} = 4.50$, $p < .048$; leg 4 $F_{1,18} = 5.92$, $p < .026$).

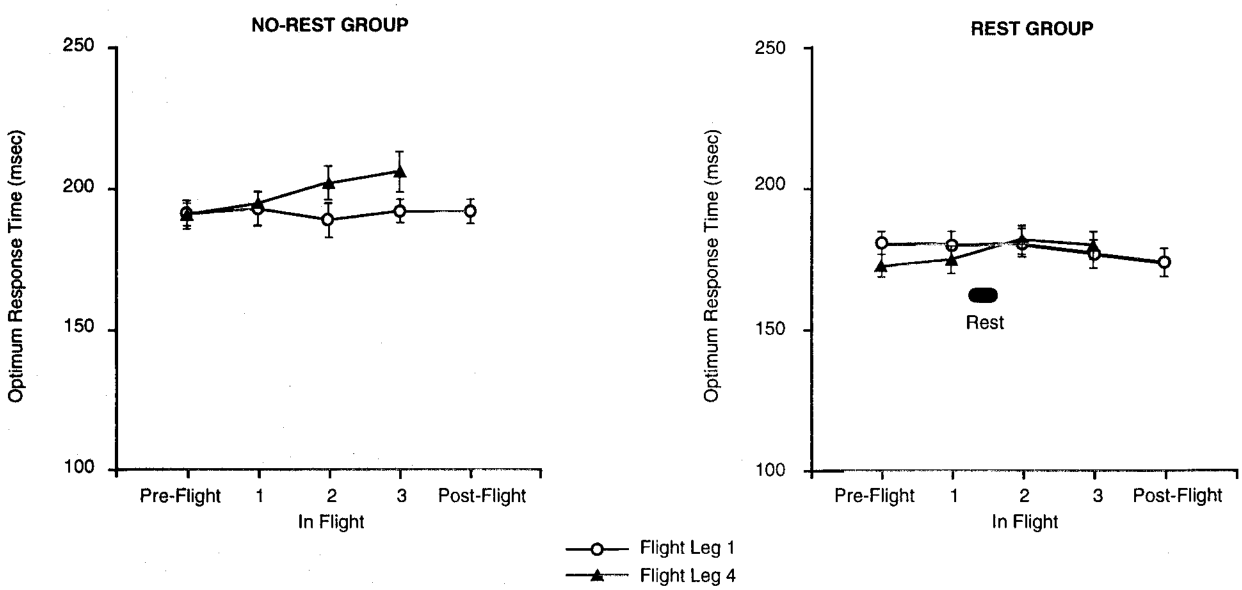

Figure 33. Mean (S.E.) optimum response times (the fastest 10% of RTs within each PVT trial) for RG and NRG for day-flight leg 1 and night-flight leg 4. Increases indicate poorer performance.

Figure 34 shows the difference in optimum responses at each trial time-point between the two groups for data averaged across the four study flight legs. Although very modest (8%), the average difference between the RG and NRG near TOD was statistically significant (the postflight difference is less meaningful owing to the absence of a postflight trial on leg 4).

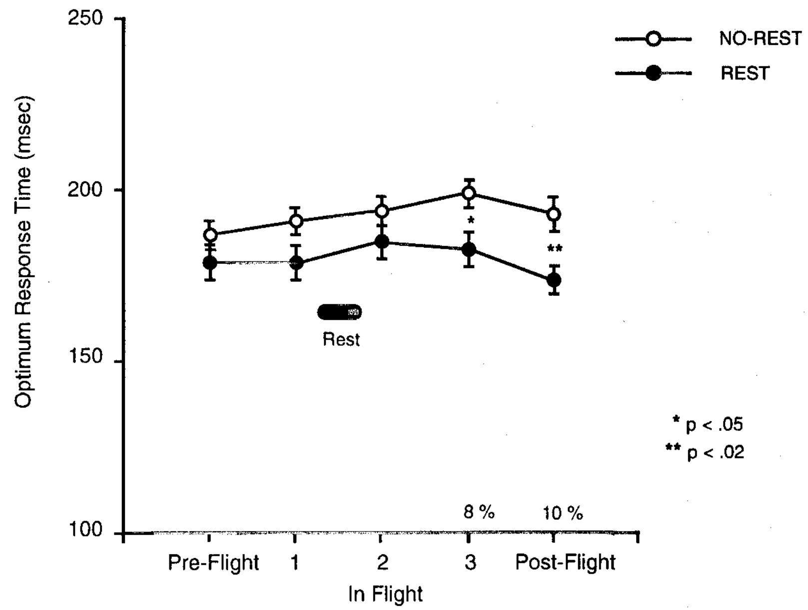

Figure 34. Mean (S.E.) optimum response times (the fastest 10% of RTs within each PVT trial) for RG and NRG collapsed across all four flight legs. Increases indicate poorer performance. Percentages indicate differences between groups' means at PVT trial times. Asterisks indicate significant differences between groups by independent t-tests at specific time points.